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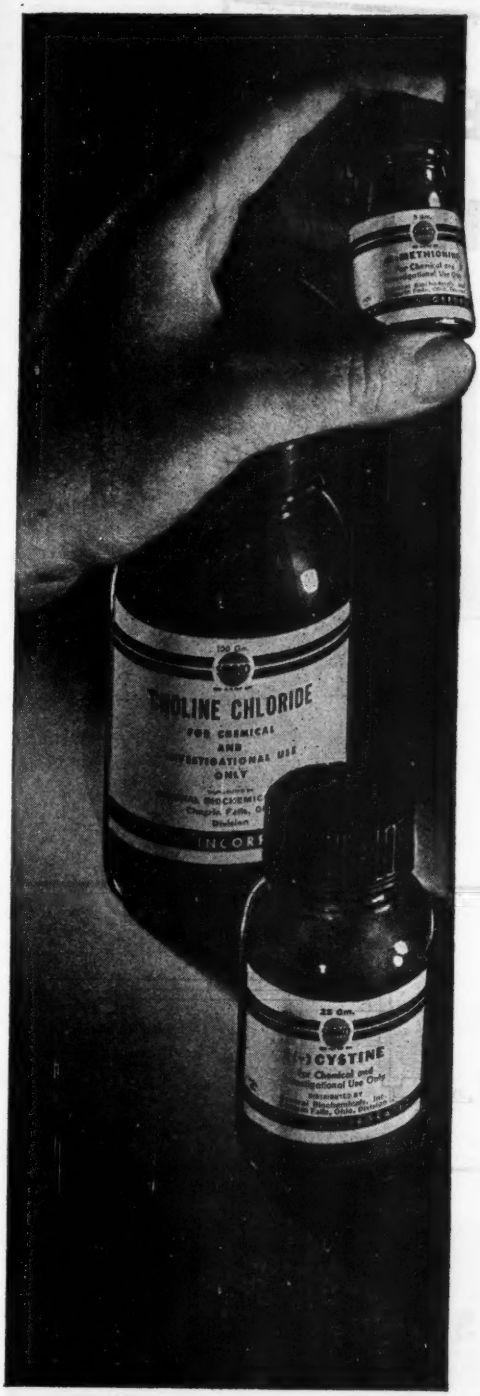

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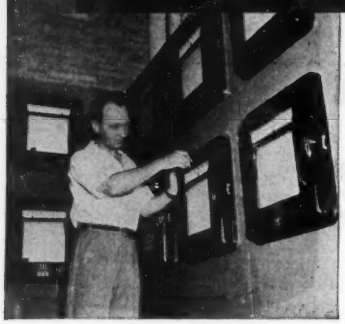

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GENERAL ASPECTS OF INTERDISCIPLINARY RESEARCH IN EXPERIMENTAL HUMAN BIOLOGY[1]

By Dr. JOSEF BROZEK and Professor ANCEL KEYS

UNIVERSITY OF MINNESOTA

INTRODUCTION

MUCH of the recent research in experimental human biology using a "total" interdisciplinary approach has received methodological stimulation from the attempt to predict what will happen, under specified conditions, to the intact human organism. In such a program the experimenter works with one "independent" variable (environmental temperature, caloric intake, vitamins, drugs, anoxia, physical work) and many "dependent" variables covering the whole gamut of biochemical, physiological and psychological responses. This type of research differs fundamentally from much of the earlier work in psychosomatics,[2] such as study of the covariation between morphological characteristics and mental traits in which statistical methods provide the sole method of investigation. The study of the effects of vitamin intake or exposure to heat is amenable to the experimental approach, also such problems are much closer to real life situations and require a more truly interdisciplinary attack.

In applied fields a genuine cooperative approach is indispensable. This is readily understandable if we realize that the emphasis is placed upon analysis and manipulation of a sector of reality, and that this reality is always multifarious. It is significant that, in modern industrial research which is concerned with the materials and the manufacturing processes, "the lone worker is being replaced by a carefully chosen corps whose various talents dovetail together and whose collective knowledge and collective analytical

[1] From the Laboratory of Physiological Hygiene.

[2] D. G. Paterson, "Physique and Intellect," New York, Century, 304 pp., 1930.

powers greatly exceed those of any single member of the group."[3] In human biology, as well, the main pressure for interdisciplinary orientation comes from the applied field. The workers in a child guidance clinic, for example, have to draw upon psychology, psychiatry, medicine, education and sociology, each of these making an important contribution to the practical working of the clinic.[4]

The investigation of the problems of human work and nutrition, research on color and sound, studies of heredity, of growth and ageing and of many other topics belonging to the field of a broadly conceived human biology yield more significant results if two or more research workers, representing different fields of specialization bearing on the particular problem, work together in a close coordination. Thus McCay, referring to gerontological work, expressed the need for pursuing a line of attack in which the physicists, biochemists, bacteriologists, nutritionists, pathologists, physiologists, histologists and psychologists work side by side: "Little hope of progress in studying the process of ageing can exist until special institutes of research are established in which whole groups of specialists will devote their lives to cooperative attempts to solve the intricate problems."[5]

Personnel Requirements

The process of scientific discovery, especially as developed in group-research, is an intriguing sociological and psychological problem. Sociological studies of human interaction which takes place in the process of scientific research reveal all basic behavior patterns (individualistic, competitive, exploitative, cooperative) which can be found in the entire field of human relations.[6, 7]

Psychologically, cooperative research has as one of its first prerequisites the sharing of some amount of factual knowledge and methodological ideas by the interacting parties. This point was brought out by Maurice L. Huggins in discussing investigation of the problems located in the borderland between biology, mineralogy and physical chemistry. He emphasized that one important condition for an effective interdisciplinary research is that "each of the cooperating scientists must have or must secure an understanding of the language, the problems, and the research methods of the other."[8] This widening of the horizon requires added expenditure of time and effort, but it pays dividends.

The reciprocal acquaintance with the methodological characteristics of the participating sciences is an important component of effective interdisciplinary cooperation. If the psychologist does not even have a remote idea of the conditions under which biochemical data are obtained—*e.g.*, how much time and care in studies of "physical fitness" it takes to make a determination of respiratory quotient or of lactic acid concentration in blood—he can not participate intelligently in planning a cooperative research program. The biochemist, on the other hand, must acquire a respect for standardization of psychological experimental conditions which differ from those of chemistry. One can curse the flame and nothing much happens—if one doesn't blow too hard. This seems trivial, but the methodological differences and peculiarities are not self-evident: the physiologist must learn to appreciate the fact that the presence of another person in a room where psychological testing is being done can make a difference and, under certain conditions, can invalidate the results.

In addition to a certain amount of common intellectual background, personality characteristics basic to team work as well as skills in cooperative planning, execution of the experiment and formulation of results are important. Some of the skills which facilitate cooperative research are identical with those required for any genuine group participation. Dr. May stressed the technique of careful and sympathetic listening to the contribution of each member of the group. The role of an active listener alternates in a discussion with that of an active talker and results in equilibrium between dominance and submission.

Successful execution of cooperative research requires modification of the competitive work habits which have been fostered by the hyper-individualistic philosophy of life expressed in the traditions of university research. University departments "compete for students, required courses, budget, size of staff, promotion of members, funds for research, space for offices and classrooms, and above all for prestige"[6] and this competitive spirit creates a barrier to interdepartmental work. A second barrier to interdepartmental cooperation is seen by Dr. May in the positional system within each department; the young scientist has a greater chance of advancement if he saws wood on his own wood pile, follows the traditional paths and works for the greater glory of his department and does not participate in interdepartmental, collaborative projects. The third barrier is formed by a set of traditional attitudes and ideas such as the

[3] F. B. Jewett and R. W. King, SCIENCE, 92: 365–371, 1940.

[4] C. M. Louttit, "Clinical Psychology, A Handbook of Children's Behavior Problems," New York, Harper, 695 pp., 1936.

[5] C. M. McCay, "Problems of Ageing," E. V. Cowdry, ed., pp. 572–623, 1939.

[6] M. A. May, "Cooperative Research," Yale University, Ms., n.d.

[7] We wish to express our gratitude to Dr. May, director of the Yale Institute of Human Relations, for making available to us the manuscript of his stimulating paper on "Cooperative Research."

[8] M. L. Huggins, *American Scientist*, 31: 338–345, 1943.

belief that scientific discoveries are always the products of individual minds, or that the cooperative setting limits the freedom of the scientist to follow the dictates of his own intellectual curiosity. The fourth barrier is a result of university training in individualistic work habits.

Thus the young scientist, who grows up in the midst of a competition between university departments and amidst competition within his department, who inherits the individualistic research tradition and graduates without having had an opportunity to develop skills in cooperative thinking and collaborative study, is poorly prepared to participate in the activities of a committee or a research team. He may have become skilful in gathering empirical data within his narrow field of specialization, but his techniques of social interaction are underdeveloped and ineffective in a practical test situation.

Because of the obstacles which stand in the way of interdepartmental research, it appears that interdisciplinary work, at least at the present time, can be carried on more effectively in institutes expressly organized for that purpose. However, these should by no means be cut off from the rest of the university. Pioneering work in this direction has been done at Yale where, in answer to the need for bridging several "anthropological" disciplines, the Yale Institute of Human Relations was created more than a decade ago. President Angell, in introducing the institute, stated that it was the result of a natural evolutionary process in which a number of separate academic groups have come to recognize their common interests and the advantages of prosecuting them cooperatively: "The purpose is to correlate knowledge and coordinate technique in related fields, that greater progress may be made in the understanding of human life from the biological, psychological and sociological viewpoints."[9] This was an important development even though not all the high hopes placed in the effectiveness of the new organization have materialized. Since 1930 other university institutes have been organized along interdisciplinary lines, although the development in some areas such as research on human work[10] has been slower than abroad.

TRAINING PROGRAM

Both competitive and cooperative behavior patterns are acquired in the process of learning. Neither is innate nor representative of the "true" nature of man.[11] The universities, yielding to requests for research workers and technicians with talent for teamwork, will have to provide training facilities which will emphasize the collaborative techniques both within and between allied departments. Over and above this pressure from the outside, there are important scientific grounds why interdisciplinary (and interdepartmental) research should become a greater concern of the universities. The assertion that institutes of an interdisciplinary character will be associated more often with industrial enterprises than with universities may be correct in the statistical sense, but it should not imply that cooperative research is an industrial prerogative.

There are two very serious reasons why the inclusion of this new research form should be a part of graduate schools: Numerous problems of a fundamental theoretical character which require a cooperative approach are not likely to be studied by industrial laboratories the very existence of which often depends upon immediate, practical results. The second reason is still more important. Industrial organizations only very rarely will provide the time and personnel to carry out a training program of high academic standards. There must be a genuine interest in acquainting the student with the full breadth and depth of the interdisciplinary research problems, which implies a full freedom to explore aspects other than those which belong to the student's immediate field of specialization. The most adequate "climate" for the training of graduate students in coperative research is a place in which such an approach is actually practiced, because there is no substitute for the method of learning by doing. At the same time, the institution in charge of the training program must be well aware of its scientific and social responsibilities and must provide stimulating supervision which is or should be a distinguishing feature of student-teacher relationship on the graduate level.

There can be much improvement in the undergraduate curriculum in the sense of broadening the background of the student and building a more interrelated sequence. Progressive education in this country has been experimenting with this idea for some time. At the University of Minnesota the attempts in this direction are closely related to progress in the field of "general education." This term usually has a broader meaning than providing a well-rounded scientific background and refers to the educational processes which aim at the development of insight, appreciation and skills needed for effective participation in a democratic society.

In terms of a committee report by Ruth E. Eckert and Horace T. Morse, general education "should give the individual an answer and understanding of problems of contemporary living, the cultural, social and technological heritage of his age, and develop in him the ability to think critically, to weigh basic human

[9] J. R. Angell, *Educational Record*, 11: 3–11, 1930.
[10] J. M. Brozek, *Federation Proc.*, 2: 134–144, 1943.
[11] M. A. May and L. W. Doob, *Bull.* No. 25, Social Science Research Council, April, 1937.

values, and to appreciate the product of creative thought and expression."[12] These aims are as valid and as important in the preparation for a scientific career as in the training of citizens for other walks of life. The idea of "general college" within the university has been offered as a means to these ends. There is a danger, of course, that the general college may serve as a refuge for those students who are unwilling or unable to pursue intensive studies. It would be unfortunate if the "general college" should simply provide a dumping ground for less capable students.

General education on the university level should (1) broaden and integrate the scientific training of the student and (2) contribute to his personal and social development. We agree with Maurice B. Visscher, when he says that the instructional staff in charge of the integrative scientific courses should be made up of *bona fide* scholars in the areas discussed. Frequently it will be difficult to find a single person with the necessary knowledge and teaching experience who could competently handle such courses. The logical alternative is a cooperative teaching program which would put into full use all the human resources of a university. "It is . . . recommended that where necessary new types of functional organizations of small groups of scholars drawn from several conventional areas of specialization be set up and that existing arrangements of this type be extended to implement the program of general education."[13] Visscher uses this approach on the graduate level in a systematic two-quarter course on Human Physiology at the University of Minnesota. General Psychology, given by Richard M. Elliott together with other members of the department, follows a similar pattern in a three-quarter course at the same university.

The problem of greater integration of college work has received serious attention at the University of Chicago. It was realized that the departmental organization "has great advantages in the training of men for specialized research and teaching in conventional and well-established fields," but "at the same time, it promotes narrowness in research and does not encourage the student to get an education broad as well as deep."[14] The consolidation of independent departments into the larger divisions (biological, physical and social sciences, and humanities) has been an important step. The next step in the direction of giving the university student a broader background has been the establishment of the Junior College which would supply an education basic to the work of all divisions and professional schools. The purpose was ". . . to mitigate the evils of premature specialization and to unite both the students and faculty in a community the members of which could have some hope of understanding each other."[14] Further arrangements are being made on the graduate level to provide an opportunity for study and research of a significantly broader scope than has been previously acceptable.[15]

The program of the Minnesota group includes the experience of working cooperatively with others as one of the purposes of general education. On the graduate level there should be provision for training in group discussion and group reporting, the use of panel presentation of seminar topics should be especially encouraged. Interdepartmental seminars will give the student opportunity to get acquainted with current research topics and methods. One of the techniques which might be used to promote cooperative research is an interdepartmental exchange of young instructors.

A meaningful course in the philosophy of science could contribute significantly to preparation for cooperative research. The situation prevailing at the universities is not far from a farce. Scientific methodology is discussed in philosophy departments where the students know of contemporary scientific research work, for the most part, only from hearsay. On the other hand, students in scientific fields learn specialized techniques but are not motivated to look beyond their own hunting grounds and underneath the surface of the "facts." We have in mind a genuine theory of scientific knowledge which should include (1) semantics—the theory of meaning and the study of verbal and non-verbal symbols used in representing scientific concepts and their combinations, (2) logic of the scientific method which deals with experimental design, collection of data, analysis of the error of measurement, process of inference and testing of hypotheses and (3) "concrete" logic or systematology of the sciences based on the analysis of their subject-matter and methods used.

For the research worker who has grown up in the traditional departmentalized university and who is anxious to take part in interdisciplinary work, the first step is to get a bird's-eye view of the neighboring fields and to obtain familiarity with the problems which are currently the foci of interest. However, text-book acquaintance is not enough; some contact with actual work methods is essential. Because of the expanse of each scientific discipline, emphasis should be placed on the methods which are actually used or

[12] R. E. Eckert and H. T. Morse, "General Education at the University of Minnesota." Mimeographed report, n.d.

[13] M. B. Visscher, "The Techniques of General Education Courses and Their Implications for Scholarship in the University," University of Minnesota, Ms., n.d.

[14] R. M. Hutchins, *Alumni Bulletin*, November 1, 1943. 23 pp.

[15] J. U. Nef, "Memorandum Concerning the Field of Social Thought," Univ. of Chicago, 4 pp., n.d.

may be used in exploration of the territory inviting an interdisciplinary approach. A benevolent tolerance is a prerequisite, but significant work can grow only out of an active cross-fertilization of scientific minds. This constitutes a very different process from presenting incoherent, parallel, non-integrated reports at a meeting of specialists.

A Case History

It may be useful to round out our discussion and to give it more reality by presenting in greater detail an interdisciplinary institute, the Laboratory of Physiological Hygiene at the University of Minnesota.

The laboratory is carrying on research in the field of a broadly conceived physiology. This includes (1) biophysics, in the larger sense, involving the study of kinetic (circulation, respiration) and electric phenomena, (2) biochemistry (metabolism, composition of food, blood and excreta), and (3) behavioral psychology covering the sensory, motor and intellective aspects, and personality.

The organization of the laboratory is built up on the conviction that a meaningful attack on the major problems of applied human physiology requires a cooperative approach. Thus physiologists, biochemists and psychologists, together with technical assistants, work as a team under the coordinating effort of a director-colleague. For many problems it is desirable to have ready consultation with members of other university departments—clinicians, physicists, chemists and engineers. The laboratory has established such collaboration as contributes materially to the scope of the problems that can be handled.

From the point of view of social organization the general scheme of the laboratory can be labeled as a "director-staff" plan. The head of the laboratory is in charge of the budget and administration, and is responsible for the general direction of the work program and the selection of major research topics. However, the staff has ample opportunity to exhibit initiative in deciding on specific action and alternatives and in selecting definite variables and techniques to measure them.

On the basis of these suggestions a general research plan is drawn up and discussed in staff meetings. The daily experimental routine is determined in minute detail, a factor of importance in long-term nutritional cooperative studies which are to meet the requirements of a rigorously controlled experimental work. Once the overall plans are laid, the execution of specific parts of the program is an individual responsibility. Staff meetings in which progress reports are presented provide the medium of integration.

Cooperative research does not mean less individual initiative or less personal responsibility. In this respect the laboratory differs distinctly from large industrial research organizations where a complex practical problem is frequently broken down into a number of researches each dealing with a single independent-dependent variable pair. The results are then synthesized by a research director who may have little contact with the separate studies. The individual research workers have little grasp of the problem as a whole and may lose sight of the ultimate aim, if, indeed, they are aware of the goal. They tend to be semi-automatic technicians only. The most fundamental objection to this method is the initial necessity for completely accurate coverage and definition of all constituent problems, and the frequent unpredictability of the behavior of the several variables when they are operating in a complex system.

Informal evening meetings of the senior staff appear to offer a particularly valuable opportunity for genuine group discussion and group thinking. Two cooperative undertakings which are still in a state of flux comprise the development of a central bibliographical file and a file of excerpts. When a staff member compiles a bibliography on a specific topic which covers a current or possible future research subject, a set of duplicate cards is made for the central file, accessible to all members, which remains a permanent possession of the laboratory. It is also planned to have a common catalogue of reprints which are the property of the individual members.

Although the main emphasis is on collaborative research (see *e.g.*,[16, 17]) the individual staff members have opportunity to pursue their scientific curiosity. There is opportunity for individual research especially if it contributes new techniques or clarifies the "background" or "foreground" of the larger work. The investigations of the effects of nutrition on the adjustment to high temperatures may be cited as an example.[18] In a "sideline" project, the physiologists studied intensively the problems of cardiovascular adjustments during exposure to dry heat.[19] The composition of sweat, an important factor in interpreting these changes, was investigated by the biochemist.[20] The psychologist utilized some of the data on functional efficiency of the human organism exposed to experimental strain (heat and hard work) in a syste-

[16] A. Keys, A. F. Henschel, O. Mickelsen and J. M. Brozek, *Jour. Nutrition*, 26: 399–415, 1943.

[17] A. Keys, A. F. Henschel, O. Mickelsen, J. M. Brozek and J. H. Crawford, *Jour. Nutrition*, 27: 165–178, 1944.

[18] A. Henschel, H. L. Taylor, J. Brozek, O. Mickelsen and A. Keys, *Jour. Trop. Med.* (in press), 1944.

[19] H. L. Taylor, A. F. Henschel and A. Keys, *Am. Jour. Physiol.*, 139: 583–591, 1943.

[20] O. Mickelsen and A. Keys, *Jour. Biol. Chem.*, 149: 479–490, 1943.

matic study on flicker fusion frequency as a test of fatigue.[21]

In the early stages of the development of the laboratory full-time participation of all staff members in the research program was necessary. It would appear advantageous that senior staff members of the laboratory should have formal appointments on a part-time basis in the respective departments of their basic interests. Such arrangements have now been made so that the senior biochemist devotes one fourth of his time to teaching responsibilities in the department of biochemistry, and so on. In addition, the laboratory as a unit should have certain definite teaching responsibilities. Through teaching a wider range of topics is covered than in specialized research and this helps to keep open the intellectual horizon. Then, too, a more direct contact with members of the "home" department should provide opportunity for further intellectual stimulation. The spirit of interdisciplinary research work, on the other hand, can be best transmitted to the students by persons who live and breathe in a cooperative atmosphere. Arrangement for internships and participation of graduate students in the research should be facilitated in this way.

An institute organized along the lines of this laboratory may play a particularly significant role in medical education. Organization of research and teaching in medical schools obstinately tends to follow the departmental structure. Also, the research is frequently limited by dependence on facilities supplied primarily for pedagogical purposes in the basic science departments and for direct diagnostic and therapeutic purposes in the clinical departments. Medical schools are commonly very inadequately equipped and methodologically not prepared for the study of important behavioral aspects of human adjustment mechanisms. This is partly due to the fact that in the orthodox medical curriculum there is, for the most part, no provision for the study of the individual human organism as an integral of anatomical and histological structures, biochemical reactions, biophysical processes, psychological motives and conditioned responses.

In the fundamental sciences the medical student is encouraged to think in terms of quantitative data, controlled conditions and experimental approach. The variables are well isolated and behave pretty much as the textbook suggests. When the student is faced with the complex organism he is apt to overcompensate for the feeling of inadequacy by calling too readily upon "intuition" when the situation calls logically for a simultaneous application of different methods covering many variables. It is realized that the step from the formal, rather abstract knowledge in the fundamental sciences to the scientific analysis and grasp of the complex problems of the patient is a difficult one. The staff of an interdisciplinary laboratory can be of much service in providing integrative lectures and seminars and detailed demonstrations. Such a laboratory presents opportunities to interested advanced students for more realistic laboratory work than is customarily available in physiology, biochemistry and psychology. Participation of graduate students and of medical graduates in the work of the laboratory should be very useful as a final preparation for both teaching and research.

Conclusions

The interdisciplinary approach is becoming one of the prominent characteristics of experimental human biology and represents a synthesizing trend which focuses the specialized research techniques on problems common to a number of separate disciplines.

Such a cooperative research has to overcome serious obstacles when operating within the existing departmentalized framework of the universities. It appears that real progress in this direction will be made in institutions which are organized on a permanent and frankly cooperative basis.

Psychologically, interdisciplinary research requires not only abstract, theoretical intelligence (and, frequently, manipulative skill) but also "social intelligence." Cooperative work is a social art and has to be practiced with patience. A team of research workers representing various disciplines can be welded into a fully integrated unit only on the basis of extensive experience of working and thinking together.

In the training program three points deserve emphasis: (1) facilities for getting acquainted with the problems and methods of the neighbor fields, (2) study of the "science of science" which provides the necessary philosophical perspective, and (3) development of social skills required for a stimulating and efficient scientific cooperation.

[21] J. Brozek and A. Keys, *Jour. Indust. Hyg. Toxicol.*, 26: 169–174, 1944.

OBITUARY

I. HUANG

A CABLEGRAM reports the recent death of I. Huang, professor of psychology in the National University of Chekiang, Tsunyi, Kweichow, China. This brings to an untimely close a valiant career which achieved much under great obstacles and which promised yet more for the New China and for intercultural relations with America.

Dr. Huang was born in Amoy, China, on November 8, 1903. He attended Tsing Hua College in Peking and South Eastern University in Nanking. At the age of twenty-two he came to California, attended Leland Stanford University, obtaining a master's degree in 1927, after graduate work under Terman and Miles. An interest in child psychology brought him to Yale University, where he secured his doctorate in 1930. As a student he displayed keen powers of analysis and a scholarly mind. He had an extraordinary command both of spoken and written English. The experimental as well as philosophical aspects of Gestalt theory attracted him and under the supervision of the late Kurt Koffka he carried out a doctoral research on "Children's Explanations of Strange Phenomena," published in *Psychologische Forschungen* (1930). This was the forerunner of a series of experimental studies now appearing in *The Journal of Genetic Psychology* on children's conception of physical causality; the role of repetition, organization and intention to learn in rote memory; abstraction of form and color in children; the size-weight illusion, and child animism. A monograph on "The Psychology of Children's Drawings" which showed impressive resemblances between the artistic productions of western and Chinese children was published in Chinese in 1938 (Shanghai Commercial Press). In addition to his teaching, lecturing and research, Dr. Huang established an experimental nursery school in Hangchow in 1935.

All these activities were carried on under almost incredible hardships. They coincided with the ruthless invasion by Japan. The University of Chekiang became a nomadic university forced to move from Hangchow to I-Shan, Kwangsi; to Tu Yun, Kweichow; and finally to Tsunyi. In the last removal, one thousand human beings and two thousand boxes of books and scientific apparatus had to be transported over one of the most uninhabitable and mountainous regions of the world, with gasoline at ten Chinese dollars per gallon! Under such conditions, personal savings melted away, and normal home life vanished. Dr. Huang and his family lived in a mud hut with straw roof, bamboo doors and holes for windows—and often in bombed areas. In spite of all difficulties, he pursued his scholarly work writing letters to America in quest of bibliographic and other details. A single page of one letter described the terrible realities of bombing, but went on to discuss "the question of perceptual constancies emphasized by the Gestaltists"! The scholar in Dr. Huang prevailed until he was overtaken by a painful and devastating illness.

Here we glimpse at once the amazing character of the Chinese people and the valor of this scientist's life. He was admired by his native colleagues and was held in affection by his students. Those who knew him in America remember his keen intelligence, his sense of humor and a certain playfulness of spirit, combined with a philosophic caste of mind.

ARNOLD GESELL

RECENT DEATHS

DR. HERBERT H. WHETZEL, professor of plant pathology at Cornell University and from 1906 to 1922 head of the department, died on November 30 at the age of sixty-seven years.

DR. CHARLES PETER SIGERFOOS, professor emeritus of zoology of the University of Minnesota, died on November 26 at the age of seventy-nine years.

PHILIP AINSWORTH MEANS, formerly associate in anthropology at the Peabody Museum of Harvard University, died on November 24 at the age of fifty-two years.

LYSTER HOXIE DEWEY, from 1890 to 1935 botanist in charge of fiber-crop investigations of the U. S. Department of Agriculture, died on November 27. He was seventy-nine years old.

WARREN L. BEUSCHLEIN, professor of chemical engineering at the University of Washington, died on September 15.

SCIENTIFIC EVENTS

THE PROPOSED BRITISH AERONAUTICAL COLLEGE

PLANS for the establishment in Great Britain of an aeronautical college at a cost of £2,610,000 in capital outlay and calling for an annual expenditure of £360,000 are given in the report of the Interdepartmental Committee on the Establishment of a School of Aeronautical Science, published on November 6. Sir Stafford Cripps, the Minister of Aircraft Production, states that the Government has accepted in principle the recommendations of the committee. According to the plan, which is described in *The Times*, London, the primary purpose of the college will be to provide high-grade engineering, technical and scientific training in aeronautics to fit students for leadership in the aircraft industry, civil aviation, the services, education and research. It is also proposed to provide shorter courses for specialists in particular subjects, refresher courses and a general "staff course" aimed at giving a broad knowledge of aeronautics.

The college would be planned on the basis of an entry of fifty students annually on a two-year course, and two hundred students on shorter courses—a total of three hundred at any one time. The instruction

would be at post-graduate level or its equivalent, research being undertaken by the staff and by selected students, attention being paid to technology as well as the science of aeronautics.

Affiliation to any university is not recommended; rather it is suggested that the college should collaborate closely with the universities, technical colleges, research establishments and industry.

The five main subjects recommended are: Aerodynamics; aircraft structures, engineering and design; aircraft equipment; engines and systems of propulsion, and production, administration and maintenance. There is also planned a department concerned with flight and operations, including full-scale experimental work and flight testing. The conditions of service of the tutorial staff would be comparable with those of a university staff. There would be no entrance examination, candidates being accepted on their merits, after interview.

THE JUNIOR ACADEMY OF SCIENCE OF WISCONSIN

THE University of Wisconsin, in cooperation with the Wisconsin Academy of Sciences, Arts and Letters, is establishing a Junior Academy of Science.

Dr. John W. Thomson, Jr., of the State Teachers College at Superior, has been appointed assistant professor of botany at the university. He will supervise the Junior Academy and will devote his time to the encouragement of scientific work at the pre-college level. The academy has appointed him chairman of its Committee on the Junior Academy, members of which will be high-school science teachers from various parts of the state.

Any student who belongs to a recognized science club in any high school in Wisconsin may become a member of the Junior Academy. It is expected that, for the time being, district meetings will be held among various state high schools. After the war it will meet annually at the same time and place as does the Wisconsin Academy of Sciences, Arts and Letters. The American Association for the Advancement of Science will grant two memberships annually to Wisconsin members in the academy.

FELLOWSHIPS OF THE TEXTILE RESEARCH INSTITUTE OF PRINCETON UNIVERSITY

FELLOWS of the Textile Research Institute of Princeton University now have the opportunity of working toward their doctor's degree at the university, so that it is expected that they will be able to meet the high standards required for admission to the Graduate School. Normally, as with other graduate students, the work for the Ph.D. degree will be completed in three years. Since Princeton does not admit women students the plan is to restrict fellowships to men—at least for the present.

Facilities and a qualified staff for the direction of advanced research will be provided at the institute building. Fellows are expected to devote the time not required in class work to the prosecution of fundamental research in one of the many fields dealing with textiles. Such studies will include investigation of the various physical and structural properties of natural and artificial fibers, of yarns and of cloth. Studies will also be made of the chemistry of fibers, of dyes and of dyeing. Other investigations will be directed toward the understanding and the control of the action of various organisms on textiles.

Contact with industry will be maintained by visits of the fellows to plants and by lectures at the institute by visitors from the industry and by the staff. It is anticipated that in problems of common interest there will be close cooperation with members of the faculty of the university.

The fellowship program is under the supervision of Professor Henry Eyring, acting director of fundamental research, the Textile Research Institute Laboratories, Princeton, N. J.

The fellowships pay $700 in addition to graduate student fees. This is in line with other fellowships at Princeton. The applicant should fill out the regular Princeton fellowship application in order that his qualifications for acceptance by the institute and by the university may be properly judged. This form may be obtained by writing to Professor Henry Eyring. The term started on November 1.

THE FOUNDATION FOR THE STUDY OF CYCLES

THE annual gold medal of the Foundation for the Study of Cycles, of which Edward R. Dewey is director, for the most valuable work on cycles published in 1943, was presented on November 24 to Henry Helm Clayton "for his monumental two-volume work, 'Solar Relations to Weather.'" In this study Mr. Clayton reprints the most important of his earlier papers and adds a new discussion of the problem of solar cycles and their possible effect upon the earth and its inhabitants.

In addition, the publications during 1943 of six investigators in other fields of cycle research are cited with honorable mention.

The presentation was made at the home of Mr. Clayton by Professor Ellsworth Huntington, of Yale University, chairman of the Committee on Awards.

Honorable mention for highly valuable publications on cycles during the year 1943 was made to the following:

To David M. Pratt, for a paper entitled "Analysis of Population Development in Daphnia at Different Tem-

peratures." (*Biol. Bull.*, v. 85, pp. 116–140, Oct., 1943.) This study provides a remarkable analysis of the mechanics by which an internal population cycle can be set up in a fresh water animal without any external cyclic variation.

To V. E. Shelford, who in 1943 published two papers dealing with cycles. One, written in collaboration with W. P. Flint, entitled "Populations of the Chinch Bug in the Upper Mississippi Valley from 1823 to 1940" (*Ecol.*, v. 24, pp. 435–455, Oct., 1943) is important particularly because it carries the history of the harmful insect back more than a century, and shows that the insect cycle is not due directly to any assignable climatic cause such as rainfall, humidity or temperature. On the other hand, it does show clearly that an increase in the number of chinch bugs is closely related to some unexplained stimulation which leads to a remarkable increase in the rate of reproduction. The problem of why this increase occurs is one of the most interesting in the whole realm of cyclic phenomena. It seems to occur not only in chinch bugs but in many other animals.

To Edward S. Deevey for his work, "Additional Pollen Analyses from Southern New England." (*Amer. Jour. Sci.*, v. 241, pp. 717–752, Dec., 1943.) This paper deals with the record of cycles preserved in the deposits of swamps and lakes, and discusses the philosophical implications of the field observations.

To Kirk Bryan and Claude C. Albritton for their paper, "Soil Phenomena as Evidences of Climatic Changes." (*Am. Jour. Sci.*, v. 241, pp. 469–490, Aug., 1943.) This discusses a method of studying climatic cycles which may prove to have wide significance, but which as yet has been only slightly developed.

To R. G. Green for the study, "Virulence of Tularemia as Related to Animal and Arthropod Hosts." (*Am. Jour. Hyg.*, 38: 262, 1943.) This has significance in connection with the effect of epidemics in reducing animal population after they have attained a high density. One of the interesting problems to be settled in the future is the relative importance of an increased rate of reproduction versus deaths from epidemics as the primary mechanism in the coming and going of cycles in animal population.

In addition to the works cited for 1943 attention is called to the remarkable study by Charles E. Elton, "Voles, Mice and Lemmings" (Clarendon Press, Oxford, 1942), which was not eligible for the 1943 awards because of an earlier publication date.

The members of the Committee of Awards as originally constituted are Dr. Charles Greeley Abbot, Smithsonian Institution; Dr. Harold Elmer Anthony, American Museum of Natural History, New York City; Professor Wesley Clair Mitchell, Columbia University; Professor V. C. Wyne-Edwards, McGill University, and Professor Ellsworth Huntington, Yale University, *chairman*.

AWARDS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

AT the sixty-fifth annual meeting on November 29 of the American Society of Mechanical Engineers Edward G. Budd, president of Budd Manufacturing Company of Philadelphia, received the Medal of the Society in recognition of his contributions to the development of the welded all-steel automobile body, his "pioneering development of the 'shotwelding' process and his work in the construction of the lightweight railroad passenger train."

Presentation of the Holley Medal for 1944 was made to Carl L. Norden, of New York, in recognition of "his invention and development of the Norden bomb sight and other valuable devices which should hasten the peace."

Earle Buckingham, professor of mechanical engineering at the Massachusetts Institute of Technology, was presented with the Worcester Reed Warner Medal. Ernest L. Robinson, engineer with the General Electric Company, received the Melville Prize Medal for original work. Dr. George W. Lewis, Washington, aeronautics authority, and Martin Goland, Jr., of the Curtiss-Wright Corporation, were awarded the Spirit of St. Louis Medal and the Spirit of St. Louis junior award, respectively.

Ralph Edward Flanders, president of the Federal Reserve Bank of Boston and president (on leave) of Jones and Lamson Machine Company, of Vermont, won the Hoover Medal, a joint award of the societies of Mechanical, Civil, Mining and Metallurgical and Electrical Engineers.

Honorary membership in the society was conferred on Dr. Charles M. Allen, professor of hydraulic engineering at the Worcester Polytechnic Institute; Major General Levin H. Campbell, Jr., chief of ordnance, United States Army; Gano Dunn, president of J. G. White Engineering Corporation; Rear Admiral Emory S. Land, chairman of the United States Maritime Commission, and Sir Standen Leonard Pearce, engineer-in-chief of the London Power Company, Westminster. Sir William Wiseman, of the British Embassy, accepted the honorary membership on Sir Standen's behalf.

SCIENTIFIC NOTES AND NEWS

THE first award of the Olney Medal of the American Association of Textile Chemists and Colorists was made on October 14 at the annual meeting of the association in Atlantic City, N. J., to Louis A. Olney, professor emeritus of textile chemistry and dyeing at the Lowell Textile Institute, for whom the medal was named. Dr. Olney is a past-president of the association and is chairman of its research committee. The

presentation was made by A. P. Howes, of the Howes Publishing Company, which endowed the medal. It will be awarded annually, or at such longer intervals as the Committee of Award may elect, for "outstanding achievement in the field of textile chemistry."

THE Daniel Guggenheim Medal has been awarded to Lawrence D. Bell, of the Bell Aircraft Corporation, Buffalo, N. Y., for his work in aeronautics, particularly in the design and construction of military aircraft, and for contributions to the methods of production. The award is made by a committee appointed by the American Society of Mechanical Engineers, the Society of Automotive Engineers and the Institute of the Aeronautical Sciences.

MAJOR CHAMP LYONS, associate in surgery at the Harvard Medical School, has been awarded the Legion of Merit in recognition of his work "by which the new and potent agent, penicillin, has been utilized in the treatment of the seriously wounded."

AT the annual meeting of the National Committee for Mental Hygiene in New York City on November 9, the first annual Lasker Award in Mental Hygiene was presented to Colonel William C. Menninger, chief consultant in neuropsychiatry of the Office of the Surgeon General, in recognition of "outstanding contribution to the mental health of the men and women of our Armed Forces."

MAJOR MERRILL MOORE, Medical Corps, U. S. Army, formerly associate in psychiatry at the Harvard Medical School and at the Boston City Hospital, has been awarded the Bronze Star Medal by Major General O. W. Griswold, Commanding General of the Fourteenth Army Corps, now in the Southwest Pacific, in recognition of "meritorious achievement in connection with military operations against the enemy in the Southwest Pacific."

THE Royal Society, London, has awarded Royal Medals to Professor D. Brunt, F.R.S., professor of meteorology at the Imperial College, South Kensington, in recognition of his fundamental contributions to meteorology, and to Dr. C. R. Harington, F.R.S., professor of pathological chemistry at the University of London, in recognition of his work in the analysis and synthesis of hydroxine and in immunological chemistry.

To mark the fortieth anniversary of the connection of Professor F. W. Coover with Iowa State College, a celebration was held on November 15. In the afternoon the presiding officer was Dr. Julian H. Toulouse, of the Owens-Illinois Glass Company of Toledo. Dr. Ralph M. Hixon, who succeeded Dr. Coover at the college, presided at the evening banquet.

IN honor of the seventieth birthday on November 27 of Dr. Chaim Weizmann, it is announced that a Weizmann Institute of Science and Technology will be established in Rehovoth, Palestine, where the Daniel Sieff Institute, which Dr. Weizmann has directed since 1934, is situated. The estimated cost of the institute is $3,000,000, toward which the sum of $250,000 already has been subscribed.

THE degree of doctor of laws was conferred on October 28, on the occasion of the inauguration of Dr. Nathan Marsh Pusey as the eleventh president of Lawrence College, on Dr. Carey Croneis, president of Beloit College, recently professor of geology at the University of Chicago. The citation reads in part: "You, in more than twenty years of teaching and research, have shown us by the men you have trained to be no ordinary teacher; by the quality and range of your published articles to be no ordinary scholar, and by the success in other activities in which you have engaged to be no ordinary administrator."

THE honorary degree of doctor of science has been conferred by Baylor University on Dr. B. F. Hambleton, professor of physiology and pharmacology, in recognition of his long service in medical education and research.

ALEX D. BAILEY, vice-president of the Commonwealth Edison Company, Chicago, has been elected president of the American Society of Mechanical Engineers.

AT the University of Minnesota, Dr. Ernst C. Abbe has been appointed chairman of the department of botany. Dr. A. Orville Dahl, instructor and tutor in biology at Harvard University, has been appointed associate professor of botany in charge of the cytological laboratory of the College of Science, Literature and the Arts.

DR. FREDERICK F. YONKMAN, chief pharmacologist of Ciba Pharmaceutical Products, Inc., Summit, N. J., has been appointed lecturer in pharmacology at the College of Physicians and Surgeons of Columbia University.

THE Department of State has granted to Dr. Muzaffer Serif Basoglu (known in this country as Muzafer Sherif), professor at the University of Ankara, Turkey, a two-year fellowship to work in the department of psychology of Princeton University on a systematic social psychology.

DR. ANDREW J. WARREN has been appointed assistant director of the International Health Division of the Rockefeller Foundation.

DR. JESSE E. HOBSON, head of the department of electrical engineering of the Illinois Institute of Technology, Chicago, has been appointed director of the Armour Research Foundation.

DR. WILLIAM J. ROBBINS, director of the New York Botanical Garden, has been elected a member of the editorial board of *The American Journal of Botany*.

DR. GEORGE S. MYERS, professor of biology at Stanford University, has returned after a period of over two years in Brazil, under the auspices of the Committee for Inter-American Artistic and Intellectual Relations. Dr. Myers acted as special adviser in ichthyology and fisheries biology to the Museu Nacional and the federal Divisão de Caça e Pesca in Rio de Janeiro. In connection with this work he organized and directed for the Brazilian Government a survey of the commercially important marine fishes and the marine fisheries of Brazil. He also examined and reported upon a site for a proposed biological station of the Museu Nacional in the Serra do Mar of the State of Espirito Santó, conducted various ichthyological and herpetological explorations for the museum in different parts of Brazil, and gave a course of lectures on Brazilian fishes in Rio de Janeiro. He is succeeded for the coming year by Dr. William A. Gosline, III, formerly a member of the staff of the Natural History Museum of Stanford University. It is expected that Dr. Gosline will return to the United States towards the end of 1945.

DR. T. C. SCHNEIRLA, associate curator in the department of animal behavior of the American Museum of Natural History, New York; associate professor of psychology at New York University, left the second week in November as fellow of the John Simon Guggenheim Foundation for southern Mexico, where he will conduct field investigations of army ant behavior in the rain forests of that region. Dr. Schneirla's previous investigations of *Eciton* behavior patterns have been confined to work carried out during the rainy season at Barro Colorado Island and elsewhere. From December through April he plans to examine the effects of dry-season conditions upon the reproductive cycle and its relation to raiding and colony movement.

FREDERICK K. KIRSTEN, professor of aeronautical engineering at the University of Washington, has leave of absence to work on proposals for the design of cycloidal propellers for marine vessels for the U. S. Navy; J. Hoover Mackin, associate professor of geology, has leave of absence to continue special work with the U. S. Geological Survey.

IN collaboration with Director Luis E. Erro and other members of the staff of the National Astrophysical Observatory at Tonanzintla, Puebla, Dr. Bart J. Bok, of Harvard University, is spending three months in Mexico in research on the southern Milky Way.

J. M. WATERSTON, plant pathologist in the Department of Agriculture of Bermuda, will spend a year at Cornell University working on the fungi of Bermuda, under the auspices of the Government of Bermuda, the New York Botanical Garden and Cornell University.

THE second annual address before the Davis Foundation for the Study of Medical History was delivered by Professor Henry Baldwin Ward. His topic was "Medical Zoology in America's First Century." The meeting was held in the auditorium of the University of Illinois College of Medicine, Chicago, on November 13. Dr. David J. Davis, dean emeritus of the College of Medicine, presided and introduced the speaker. Before the meeting Dr. Ward was tendered a luncheon by a group of his colleagues from the medical faculty of the university and guests.

DR. JEAN OLIVER, professor of pathology at the Long Island College of Medicine, will deliver on December 21 the third Harvey Society Lecture of the current series at the New York Academy of Medicine. He will speak on "New Directions in Renal Morphology—A Method, its Results and its Future."

THE Wilbur Wright Memorial Lecture for 1945 will be delivered before the Royal Aeronautical Society, London, on May 31, by T. P. Wright, director of the Aircraft Resources Control Office of the United States Aircraft Production Board.

DR. OTTO LOEWI, research professor of pharmacology at the New York University College of Medicine, gave the Edward Gamaliel Janeway lectures at Mount Sinai Hospital on November 13 and 15. The subjects of the lectures were "Aspects of the Transmission of the Nervous Impulse" and "Theoretical and Clinical Implications."

THE Office of War Information has arranged for a series of recorded talks by American scientific men to be broadcast to China by short-wave transmission to give information concerning recent developments in various fields of research, thus helping to mitigate the isolation rendered inevitable by war conditions. The first series, under the chairmanship of Dr. David E. Green, included the following speakers: Professor Claus W. Jungeblut, Viruses; Dr. T. Hunter, Clinical Applications of Penicillin; Dr. T. Jukes, Vitamins; Dr. H. Rose, Rickettsial Diseases; Professor A. B. Gutman, Plasma Proteins; Dr. J. P. Webster, Plastic Surgery; Dr. R. O. Roblin, Jr., Chemotherapy; Dr. E. Kabat, Immunochemistry, and Dr. C. G. King, Nutrition.

THE National Research Council announces that fellowships in mathematics, astronomy, physics, chemistry, geology, paleontology, physical geography, zoology, botany, agriculture, forestry, anthropology and psychology will be available for the year 1945–1946. These fellowships are awarded as a rule to persons

under thirty-five years of age who are citizens of the United States or Canada, and who have met all the requirements for the doctor's degree. Applications must be filed on or before December 31, on forms obtainable from the secretary of the Fellowship Board in the Natural Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. A handbook describing the fellowships—stipends, conditions and tenure—will be furnished upon request.

THE two hundred and sixty-fourth meeting of the American Physical Society will be held at the California Institute of Technology, Pasadena, on December 16.

THE Committee on Arrangements of the Hormone Conference of the American Association for the Advancement of Science is preparing for a meeting at Mont Tremblant, Quebec, in September, 1945. The papers and discussion of the 1944 meeting will be published in the spring of 1945. The Committee on Arrangements consists of Drs. Robert Bates, R. D. H. Heard and Gregory Pincus, *chairman*.

FREDERICK STEARNS AND COMPANY has made a grant of $1,800 to establish for the coming year at the School of Medicine of the University of Georgia a fellowship in pharmacology for the investigation of uterine antispasmodics.

DISCUSSION

THE HARVARD APPARATUS COMPANY, THE AMERICAN JOURNAL OF PHYSIOLOGY AND DR. W. T. PORTER

THE undersigned, having on the request of W. T. Porter assumed the guidance of the Harvard Apparatus Company, wish to place on record Dr. Porter's unique services to science. Some forty-five years ago, when there was scant if any laboratory teaching of physiology in our colleges and universities outside the medical schools, and laboratory teaching of physiology in medical schools was just emerging, Dr. Porter saw the probable importance of rendering available to our colleges, universities and medical schools good apparatus at the lowest possible cost for the laboratory teaching of physiology. Such laboratory experiments by students required many pieces of apparatus, accurate enough for reliable experimental results and inexpensive enough for very limited budgets. Such apparatus did not then exist. But Dr. Porter saw that it could be made by quantity production. So, much new apparatus was invented, and many classical instruments were redesigned to fit them for quantity production by special tools. It was for this great task that the Harvard Apparatus Company was formed. A great task, because it was foreseen that quantity production would give a surplus for other schools throughout the nation. Dr. Porter started the Harvard Apparatus Company as a private corporation, partly on borrowed funds. This business has been conducted by Dr. Porter in the public interest and without commercial profit. When there was a modest surplus, this was used: (a) to improve production equipment, (b) to provide a pension fund for the company's employees, and (c) to finance the W. T. Porter Research Fellowship in Physiology, administered by the council of the American Physiological Society. We intend to continue these policies. The research fellowship was started by Dr. Porter in 1920, and to date the Harvard Apparatus Company has paid to the American Physiological Society approximately $28,000 for this fellowship fund. So far this annual fellowship has been awarded to qualified young investigators working in well-equipped laboratories in the United States and in Canada. We feel sure that the council of the American Physiological Society will give due consideration to applications from qualified young investigators in other countries working in well-equipped laboratories in other lands.

In 1929 Dr. Porter offered the Harvard Apparatus Company as a free gift to the American Physiological Society. The society did not consider it feasible to undertake the management of the company. But the council of the society at that time said: "There is no one agency, during recent years, which has contributed more to the sound teaching in experimental physiology in this country than has the Harvard Apparatus Company."

In 1934 the Harvard Apparatus Company was reorganized as a non-profit corporation under the laws of the State of Massachusetts "for the promotion of teaching and research in physiology and its allied sciences." Dr. Porter gave to this corporation all property owned by the private Harvard Apparatus Company corporation. Dr. Porter has received no salary for his services to the corporation. We intend to follow Dr. Porter's example, with (we hope) some of Dr. Porter's efficiency and vision. In recent years the services to the sciences of functional biology rendered by Dr. Porter within our own borders have been extended to many other countries. The services of the company can be further extended to the liberal arts colleges, junior colleges and high schools where experimental physiology has not yet been introduced as an element of a liberal education, a forward step in the education of to-morrow, probably in the cards.

Forty-six years ago Dr. W. T. Porter founded *The American Journal of Physiology* (for the publication

of research), and for sixteen years he carried the entire financial responsibility and editorial burden for the first thirty-three volumes, that is, until 1914, when Dr. Porter presented this journal (including back volumes in stock) as a gift to the American Physiological Society.

These are significant services to science and to our fellow men. They call for more than a passing note, as they echo and amplify the voice of the English chemist, James Smithson of a hundred years ago, whose vision of science, whose faith in man and whose material wealth established the Smithsonian Institution of Washington, *"for the increase and diffusion of knowledge among men."*

A. J. CARLSON
UNIVERSITY OF CHICAGO
PHILIP BARD
THE JOHNS HOPKINS UNIVERSITY
WALTER E. GARREY
VANDERBILT UNIVERSITY
F. W. WEYMOUTH
STANFORD UNIVERSITY
MAURICE B. VISSCHER
UNIVERSITY OF MINNESOTA

ENTOMOLOGY IN WAR-TORN CHINA

ENTOMOLOGY, along with other sciences, is suffering greatly in China under the pressures and privations of the war, which for China has lasted so long and been so hard. The war has not only destroyed so much in the way of university buildings, libraries, laboratory equipment, insect collections and the like, and forced the moving or repeated moving of nearly all the educational and research institutions of the country, but has almost completely closed the sources of supply of literature, equipment and materials from the outside world. The economic situation within the country, together with the restrictions of war, have totally prevented or greatly hampered the manufacture of equipment and the reprinting of books. Thus the student, teacher, research specialist, medical entomologist and agricultural extension worker have all had to attempt to pursue their work against almost insuperable odds.

Furthermore, American contributions to Chinese entomology have been in a way more hampered than the field as a whole. This is partly because some of the institutions in which Americans participate did not move to West China during the early part of the war before American entry. This was because they enjoyed some immunity from the Japanese, or found it convenient to move to, or remain in, places like the International Concession in Shanghai, or the British colony of Hong Kong, and resulted in their being caught with the coming of Pearl Harbor. Likewise, some of the American teachers who were in Free China have had to return home for health or other reasons, including the difficulty of adequate financing as a result of the extreme inflation in China.

The following excerpts from a recent letter from Professor B. A. Slocum, professor of entomology in the College of Agriculture of the University of Nanking, at Chengtu in Szechuan Province, can perhaps more graphically emphasize the grave situation of entomology in China to-day:

> Entomology is marking time right now, for we do not have funds for research work. We are having trouble even to secure funds for the research of our graduate students. . . . Our university is having to let 21 per cent. of our staff go this summer. We have cut everything to the bone. For example, I had only $5,000 Chinese currency [less than US$50.00, officially, or under US$20.00 on the black (open) market] for my whole division this past year. Right now we are trying to sell equipment to keep going. It is difficult to keep up the morale of the staff under such conditions. . . . My division is opening an insecticide laboratory this summer. One of my students who just received his M.S. minoring in industrial chemistry will have charge of it.

Letters from others indicate that most of the universities or scientific institutions are in the same state to a greater or lesser degree. Some have been cut off from the rest of Free China by the recent merger in Kwangsi of Japanese forces from Hunan and Kwangtung, and fear they may have to close or try to move again. Letters from some have urged that scientists in this country collect duplicate literature or equipment to send to China as soon as circumstances permit.

American aid to Chinese entomology (or other sciences) during this critical period can be of great value, not only in reviving and strengthening it and helping in the solution of many pressing problems, but it can also react with beneficial results in America. Chinese entomologists have contributed much to world entomology, and will do so much more in the future, and the making known of their pests, beneficial parasites and insecticides, and the solution of their problems in medical entomology, can be of great benefit to America as well as to the Orient. If this country can give literature, equipment and specimens, and arrange scholarships and exchange of students, professors and research specialists, those objectives can sooner be attained, with much mutual benefit, including progress towards an harmonious world society.

J. LINSLEY GRESSITT
DIVISION OF ENTOMOLOGY AND PARASITOLOGY,
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THE THREAT TO PURE SCIENCE

THE article "The Threat to Pure Science" by Alexander Stern[1] raises a number of questions relative to

[1] A. W. Stern, SCIENCE, October 20, 1944.

the basic nature and function of science which, in my opinion, merit further discussion. The importance of such a discussion is underlined by the fact that many of Dr. Stern's views are shared in one form or another by a not inconsiderable group of research workers in many fields. I should therefore like to discuss several aspects of the problems posed by Dr. Stern.

The question of "pure" science versus "applied" science is a question which does not have real roots in life. Like the unicorn "pure" science is a myth. If by "pure" science is meant science unconnected with and not dependent upon any other phase of human activity, existing by, with and of itself, it is obvious that there has never been any such type of science.

If, on the other hand, by "pure" science is meant work that is done without regard for immediate practical applicability then it is obvious that what we are dealing with is an attitude on the part of the scientist doing the work rather than a basic characteristic of the work itself. This is so because all scientific work stems from work in a real world and therefore must have some applicability to the real world. The exact relationship of the work to practical affairs may at a given time be obscure, but the history of science is replete with examples of "pure" science that in time were of the greatest practical moment. Indeed, ironically enough, this is one of the chief justifications of those who carry the banner of "purism."

Let us discuss this attitude of disregard for practical applicability a little more deeply. By practical applicability we generally mean work that will help greater numbers of men lead richer, fuller, more comfortable lives. It seems most understandable that the majority of mankind will feel more in sympathy with those who would consciously contribute to the advancement of mankind than those who in effect say, "Mankind go hang. I am looking for intellectual stimulation and personal satisfaction."

The attitude of the "purists," as summed up by Dr. Stern, bears startling resemblance to the basic philosophy of those who play chess professionally. Chess is an absorbing game which has from the standpoint of number of conceivable moves infinite possibilities. To play chess well one must have the qualities which Dr. Stern considers necessary for great scientists, namely, "reason, detachment and understanding." And yet it is well known that chess is but a game; fascinating, it is true, but a game nevertheless, played by arbitrary man-made rules, and most great scientists, I am certain, would hesitate to spend a lifetime playing chess.

The chief difference between being a chess player and a scientist is, of course, that consciously or not the work of the scientist contributes to the advancement of mankind, and it is for this reason that being a scientist is generally regarded on a higher plane than playing chess.

I believe that it is a more proper attitude for a scientist to understand his relation to the world he lives in, to acknowledge his debt to all past science and human endeavor (without which his work would be impossible) and knowingly to contribute his work to the betterment of the present and the promise of the future rather than smugly to raise a false cry of "purity" or "intellectual satisfaction."

Sir Isaac Newton expressed somewhat the same thought when he said, "I stood on the shoulders of giants," as did John Donne when he wrote, "No man is an Iland, intire of it selfe; every man is a peece of the Continent, a part of the maine. ——— I am involved in Mankinde."

I should also like to discuss the question of "freedom of science" as posed by Dr. Stern and previously enunciated by Dr. Bridgman.[2] Some years ago Dr. Bridgman[3] called for the adoption of the operational analysis of physical concepts. By this he meant that each concept and question in modern physics required reduction to the specific operations in the real world giving rise to and defining the given concept. It is unfortunate that Dr. Bridgman did not extend his brilliant contribution toward solid thinking in physics to the question of "freedom of science." For by operational analysis it can be seen that science can never be independent of the society in which it exists.

Let us for example analyze the degree of freedom of science existing in the universities in free countries which is the desired, acceptable standard adopted by both Dr. Stern and Dr. Bridgman.

University research funds are paid for by either government subsidy or private endowment. Should the occasion arise when there would be an irreconcilable clash of policy between the object of the research and the endower of the research it is the research which would suffer. It is needless to say that these clashes do occur and that research does suffer.

Or let us look at the problem from another viewpoint. In 1932 and 1933 universities did not have much money to spend for research. So as a result thousands of would-be researchers did not fulfil their desires and much work of inestimable value was lost.

Is it not clear that the amount and kind of research depends partly on the economic and political level of a given society? The greatest threat that exists to science to-day is the possibility that we may not be able to build a politically and economically stable postwar world which will allow for the maximum expansion of facilities for research.

[2] P. W. Bridgman, SCIENCE, July 21, 1944.
[3] P. W. Bridgman, "The Logic of Modern Physics."

Further it may be seen that the question of whether this type or that type of organizational set-up for research is better can only be answered on the basis of a specific analysis of what the given organizational set-up would entail.

For example, to evaluate government supervision of research or corporation supervision of research one should determine the type of government, or corporation, the basic objectives of the supervision, who would be in charge of administering the supervision, what funds would be available for research, etc. Such an analysis when applied to universities reveals as many differences in degree of freedom as would be found in the case of governments or corporations. The chief point is that the most constructive attitude here is an open-minded scientific specific analysis rather than one based on general terms which have very few ramifications in actual practice.

EUGENE V. D. ROBIN

MAY I commend you, and Mr. Stern, for his communication on "The Threat to Pure Science" in your issue of October 20, 1944? It seems to me that the point he has raised is a crucial one. The emphasis in America has been on applied science and technology rather than on pure science, but is not all applied science the application to practical uses of the principles discovered in pure science? As Whitehead has well said, our utmost abstractions are the most powerful weapons with which we control concrete fact. The paradox consists in the circumstance that the greatest practicality can be obtained only if we pursue pure science quite independently of its practical usefulness. The fact that some pure sciences are indifferent to and even disdainful of application does not prevent their work being eventually highly useful. If, in America, we do not pursue pure science along with practical and applied science, we will not continue to make advances because we will not have any future pure science on which applications could draw, so from the narrow viewpoint of practicality, the detached pursuit of pure science is an absolute necessity.

Practical experience seems to bear this out, for in the absence of pure science on which the industrial laboratories could count, they themselves have been forced more and more to add theoretical researches to their programs. However, there is no reason why pure science should have to be conducted surreptitiously or expeditiously, for it can not under those circumstances do its best work. Things can not be properly related that are not sufficiently distinguished from each other. A pure science which pursued its course indifferent to the demands of society for usefulness would eventually prove the most useful investment that society could make, even though such an investment may have to be amortized over a period of years.

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SCIENTIFIC BOOKS

A CATALOGUE OF VASCULAR PLANTS

Catalogue of the Vascular Plants of S. Tomé (with Principe and Annabon). By A. W. EXELL. xi + 428 pp. 26 figures. 3 maps. London: British Museum (Natural History).

FERNANDO PO, Principe, S. Tomé and Annabon form a group of small equatorial islands in the Gulf of Guinea close to the coast of West Africa. This catalogue is a model of what such a work should be. It is manifest that the author and his associates have made a serious attempt to account for all species previously credited to the islands covered, and at the same time have determined by a study of types and the early literature the proper status of many early names, some of which have been consistently misapplied since 1753. Adjustments in the application of widely used names in *Corchorus, Canavalia, Caesalpinia, Dichrocephala, Eclipta, Quamoclit, Ipomoea, Fimbristylis, Cyperus* and other genera for various pantropic species require that all individuals concerned with tropical floras consult this work if they are at all interested in the proper application of early published binomials. As examples, *Kyllinga pumila* Michx. becomes *Cyperus tenuifolius* (Steud.) Dandy, *Cyperus umbellatus* Benth. = *Mariscus umbellatus* Vahl becomes *Cyperus sublimis* (C. B. Clarke) Dandy, *Cyperus odoratus* Linn. stands for an entirely different species than that to which this name has long been erroneously applied, and what has long been miscalled *C. odoratus* becomes *Cyperus polystachyos* Rottb., and *Fimbristylis dichotoma* (Linn.) Vahl replaces *F. diphylla* (Retz.) Vahl and *F. annua* All., the Linnean name previously misapplied by most authors. The synonymy is critically assembled. Changes made in the names of various species are strictly in accord with the International Code of Botanical Nomenclature. The total number of species is not large, about 820 in all, including the introduced cultivated and naturalized ones. It is of interest to note that of these about 230, or about 28 per cent. also occur in the Philippines, separated from the Gulf of Guinea by the African continent, the Indian Ocean and the Malay Archipelago; about 50 of these are of

natural distribution and 180 man-distributed (weeds and cultivated plants).

The introductory chapters are replete with information regarding the islands, climate, topography, plant formations, history of botanical exploration, origin and affinities of the flora, etc. As noted by the author, S. Tomé was uninhabited when it was discovered by the Portuguese in 1470–71, and thus it has been possible to make some pertinent observations on the effect of man on the natural vegetation within a known period. By transfer seventy-five new names are published, and thirty-five new species are described, the new names being largely due to the critical bibliographic and herbarium work of the author and his associates. *Aidia* Lour. 1790 is reinstated as a valid genus, type *Aidia cochinchinensis* Lour. (*Randia cochinchinensis* Merr.; *Randia densiflora* Benth.), the group hitherto having been included in *Randia* Linn.

E. D. MERRILL

CHEMICAL MACHINERY

Chemical Machinery. An Elementary Treatise on Equipment for the Process Industries. By EMIL R. RIEGEL. vii + 583 pages. New York: Reinhold Publishing Corporation. 1944. $5.00.

IN its twenty-seven chapters this volume covers some twenty-three general types of process equipment. Also included is a three-chapter section on instruments for measuring and controlling temperature, pressure, flow and other process variables. The coverage of general types of equipment, *i.e.*, agitators, heat exchangers, filters, crystallizers, evaporators, etc., is quite complete. The book is well illustrated by the 436 photographs and line drawings which it contains. The material presented is up to date and the inclusion of cost figures with corresponding dates will be valuable in the preparation of rough cost estimates. References are included at the end of each chapter which will prove helpful to any one interested in a detailed discussion, particularly of the theoretical aspects, of the design of equipment. Theoretical discussions are almost entirely lacking and those few included are most elementary and incomplete.

This book will be helpful to any one interested in acquainting himself with the various kinds of equipment available for carrying out such operations as drying, size reduction, distillation, pumping, etc. It will enable him also to get some idea of the size and capacity, as well as the cost, of process equipment as used on a production scale. As a general descriptive survey of the process equipment field it fills a certain need in the literature of chemical engineering.

There is a tendency in the book toward lack of precision of statement which makes the presentation sometimes confusing and occasionally misleading. Technical terms are often introduced without definition and many unwarranted generalizations are made. Read with some background of training or experience in chemical engineering these difficulties are not serious.

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SPECIAL ARTICLES

RELATION OF THE STREPTOCOCCUS LACTIS R FACTOR TO "FOLIC ACID"

RECENTLY, the isolation of a growth factor for *Streptococcus lactis* R (SLR factor) was reported, which effectively replaces "folic acid" in the nutrition of this organism but is inactive for *Lactobacillus casei*.[1]

It has since been found that folic acid[2] is formed when *S. lactis* R is grown in a folic acid-free medium containing the SLR factor. The presence of folic acid in such cultures is shown by the fact that the whole culture, the cells or the culture fluid, when added in adequate amounts to folic acid-free media, support maximum growth and fermentation of *L. casei* and other folic acid requiring lactic acid bacteria. Table 1 gives results obtained with the supernatant fluid of a centrifuged culture of *S. lactis* grown for 1 day in media containing the SLR factor.

It is evident that the *S. lactis* R factor, although present in a concentration 100 times that required for optimum growth of *S. lactis*, can not replace folic acid for the lactobacilli. However, growth of *S. lactis* in a medium containing the SLR factor results in the formation of sufficient folic acid per cc to permit acid formation by the lactobacilli equal to or greater than that obtained with 0.003γ units of folic acid.

It is possible that the SLR factor stimulates *S. lactis* to synthesize folic acid from the other constituents of the medium. However, it seems more likely that the SLR factor, *per se*, is transformed into folic acid since the amount of folic acid formed increases as the quantity of SLR factor in the medium is raised even considerably beyond that required for maximum growth of the organism. Moreover, folic

[1] J. C. Keresztesy, E. R. Rickes and J. L. Stokes, SCIENCE, 97: 465, 1943.

[2] The term "folic acid" is used because activity was compared to that of a folic acid concentrate kindly supplied by Dr. R. J. Williams. However, the term is used in this paper to include any substance which can replace folic acid in the growth of *L. casei*. *Cf.* E. E. Snell and W. H. Peterson, *Jour. Bact.*, 39: 273, 1940; J. J. Pfiffner *et al.*, SCIENCE, 97: 404, 1943; R. L. R. Stokstad, *Jour. Biol. Chem.*, 149: 573, 1943; B. L. Hutchings *et al.*, SCIENCE, 99: 371, 1944.

TABLE 1
ACID FORMATION BY "FOLIC ACID" REQUIRING LACTOBACILLI IN VARIOUS GROWTH FACTOR MEDIA

Organism	Addenda to 10 cc of basal medium*			
	Nil	SLR factor 0.3γ units†	"Folic acid" 0.003γ units†	1 cc culture fluid of *S. lactis* R grown with 0.3γ units of SLR factor per 10 cc of medium
	cc. N/10 acid formed in 3 days at 37°			
Lactobacillus casei	1.1	0.8	6.5	7.0
Lactobacillus delbrückii LD5	1.9	1.6	7.7	8.7
Lactobacillus casei 19	1.0	0.9	2.5	2.4
Lactobacillus bulgaricus 05	1.8	1.4	7.4	8.5

* Essentially as described by Landy and Dicken, *Jour. Lab. Clin. Med.*, 27: 1086, 1942.
† Using *S. lactis* R, the activity of the SLR factor was standardized against a folic acid concentrate. One "microgram unit" is equivalent to one microgram of folic acid of "potency 40,000." For definition of the latter see H. K. Mitchell and E. R. Snell, *University of Texas Publication* No. 4137, 36, 1941. One microgram of factor SLR is equivalent to approximately 5γ units of folic acid.

acid can be readily produced by adding washed cells of *S. lactis* to a water solution of the SLR factor and incubating the mixture for 3 to 4 hours at 30° C. Under such conditions cell growth is largely eliminated.

A survey of factor SLR and folic acid requirements of a number of lactic acid bacteria revealed that *Streptococcus fecalis* 732, *Streptococcus fecalis* F24, *Streptococcus zymogenes* 5C1 and *Streptococcus durans* 98A, also, can develop with either the SLR factor or folic acid (Table 2). Growth of these strep-

TABLE 2
STREPTOCOCCUS LACTIS R FACTOR AND FOLIC ACID REQUIREMENTS OF LACTIC ACID BACTERIA

Factor SLR or folic acid (interchangeable)	Organisms requiring: Folic acid	Nil
Streptococcus lactis R	*Lactobacillus casei*	*Lactobacillus arabinosus* 17–5
Streptococcus fecalis 732*	*Lactobacillus delbrückii* LD5	*Leuconostoc mesenteroides* 6205†
Streptococcus fecalis F24*	*Lactobacillus bulgaricus* 05	*Streptococcus lactis* 374† 4487† 7962† 8039† 7963† 4386† L103* L104* L206*
Streptococcus zymogenes 5C1*	*Lactobacillus casei* 19	*Streptococcus fecalis* 10C1
Streptococcus durans 98A*	*Streptococcus fecalis* S108A*	*Streptococcus zymogenes* 6054†

* We are greatly indebted to Dr. J. M. Sherman of Cornell University for these cultures. Their folic acid requirements have been determined by Dr. Sherman (personal communication) and our results confirm those obtained by him.
† Obtained from the American Type Culture Collection.

tococci in SLR factor medium is accompanied, in every case, by formation of folic acid. Some lactic acid bacteria, primarily lactobacilli, can not utilize the SLR factor and must be supplied with folic acid for growth. However, the majority of the strains examined do not require either factor for growth, presumably because they are able to synthesize folic acid. Synthesis of folic acid was established for *Lactobacillus arabinosus, Leuconostoc mesenteroides* and *Streptococcus fecalis* 10C1.[3]

As indicated in Table 2, folic acid can replace the SLR factor for all bacteria which can utilize the latter. Also, in every instance folic acid is formed when such organisms are grown with the SLR factor. It, therefore, seems probable that the latter is biologically active because it can be converted to folic acid. If this is the case, the rate of conversion of factor SLR to folic acid must be very rapid, since the rate of growth of *S. lactis* R in media containing these factors is essentially the same[4] (Fig. 1).

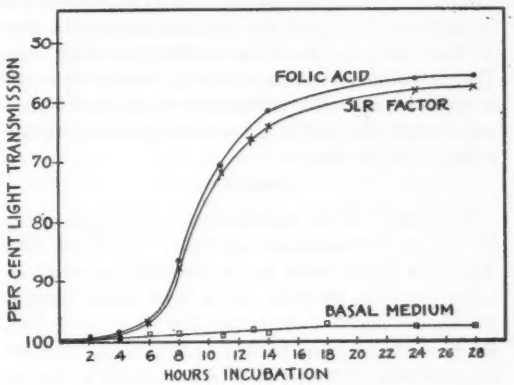

FIG. 1. Rate of growth of *Streptococcus lactis* R in SLR factor and "folic acid" media.

The *S. lactis* R factor, unlike xanthopterin, does not give rise to folic acid when incubated with rat liver suspensions.[5,6]

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THE EFFECT OF ATROPINE SULFATE ON THE COURSE OF INFLUENZA VIRUS INFECTION[1]

IN an investigation of the influence of various factors on the resistance of experimental animals to in-

[3] *Cf.* B. L. Hutchings, N. Bohonos and W. H. Peterson, *Jour. Biol. Chem.*, 141: 521, 1941.
[4] 0.015γ units of each growth factor per 10 cc of medium was used. The cultures were incubated at 30° and growth was measured in an Evelyn photoelectric colorimeter.
[5] L. D. Wright and A. D. Welch, SCIENCE, 98: 179, 1943. An increase in folic acid was obtained with xanthopterin which confirms the results of Wright and Welch.
[6] We are indebted to Miss Marion Gunness and Mrs. Alma Larsen for capable assistance, and Messrs. E. L. Rickes and L. Chaiet for the preparation of the *Streptococcus lactis* R factor.
[1] This work was aided by a grant from the Kresge Foundation.

fluenza A virus infection, it was observed that the administration of a solution of atropine sulfate exerted a marked effect on the course of such infections.

METHOD

The PR–8 strain of influenza A virus[2] was used in these experiments, and mice were inoculated under light ether anesthesia by the intranasal instillation of 0.05 ml of a 1:100,000 dilution of a suspension of infected mouse lung. This inoculum contained approximately 1 m.l.d. of virus. Mice treated with atropine were given 1.0 mg of the drug intraperitoneally. On the basis of the relative toxic dose for man[3] and mice,[4] it was estimated that this amount was approximately 30 times the calculated therapeutic dose for the mouse and about one sixth of the toxic dose. The atropine was administered at various intervals both before and after intranasal instillation of virus under ether anesthesia. All surviving mice were sacrificed after 10 days.

RESULTS

The results of the administration of atropine may be seen in the accompanying table. When the drug was given twelve hours before the virus inoculum, no effect could be detected. If it were given between 15 minutes and 6 hours before the virus instillation, fewer of the atropine treated animals died, the mean survival time of those which did succumb to the infection was greater, and the incidence and extent of the lesions in the treated animals were less than in the controls. The longer the interval between the administration of atropine and virus inoculation, the less marked was this effect. When the atropine was given twelve hours before the virus instillation, the effect could no longer be observed.

Further, atropine administered even as soon as 5 minutes after ether anesthesia and intranasal instillation of virus apparently did not influence the course of the infection. The mortality and extent of the lesions were approximately the same in the treated and untreated mice.

DISCUSSION

Several possible explanations of the ability of atropine to increase resistance to influenza virus infection might be postulated. It has been shown that the resistance of hamsters to influenza virus may be decreased by the intra-tracheal inoculation of virus suspended in gastric mucin[5] or mucus secretions.[6] If one assumes that aspiration of mucus secretions, present in excess following ether anesthesia, may aid in the establishment of the virus infection, then if this excessive secretion were inhibited by the action of atropine, infection would be less likely to occur. Although experiments dealing with the effect of mucin on influenza virus infections were not performed with mice, because of the small size of the trachea, it is believed that susceptibility to influenza virus is greater following ether anesthesia, which is associated with increased mucus secretions of the irritated respiratory tract.

TABLE 1

EFFECT OF INTRAPERITONEAL ADMINISTRATION OF 0.1 ML OF 1 PER CENT. ATROPINE SULFATE SOLUTION AT VARIOUS TIME INTERVALS ON RESISTANCE OF MICE TO INFLUENZA A VIRUS

Time of Administration in relation to virus inoculation.	Number inoculated with virus	Per cent. of deaths	Average time of death in days	Per cent. of animals with pulmonary consolidation among surviving animals		
				100–50 per cent.	49–1 per cent.	0
15 min. before	71	22	7.7	28	18	31
No atropine	63	58	5.8	29	11	3
1 hr. before	29	24	6.8	27	24	24
No atropine	25	44	5.5	40	12	4
3 hrs. before	19	21	8.0	26	32	21
No atropine	17	41	7.0	41	12	6
6 hrs. before	17	47	6.8	24	12	18
No atropine	14	50	7.0	28	14	7
12 hrs. before	17	70	5.5	12	12	6
No atropine	13	61	5.5	23	16	0
5 min. after	44	57	7.0	35	7	2
No atropine	48	52	6.9	31	15	2
10–20 min. after	31	54	7.2	35	10	0
No atropine	30	36	7.5	43	20	0

The administration of atropine after ether anesthesia and virus inoculation did not affect the course of the infection. This is in accord with earlier work from this laboratory,[7] in which it was found that atropine had no effect on the course of experimental pneumococcus pneumonia when the drug was given after the onset of the disease.

SUMMARY

It has been shown in mice that the administration of atropine sulfate intraperitoneally before the intranasal instillation of influenza A virus decreased the incidence and extent of infection of these animals.

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[2] Obtained through the courtesy of Dr. Thomas Francis, Jr.

[3] T. Sollmann, "A Manual of Pharmacology," 5th Edition. Philadelphia: W. B. Saunders Company, 1936.

[4] M. A. Wilberg, *Bioch. Zs.*, 66: 389, 1914.

[5] A. H. Wheeler and W. J. Nungester, SCIENCE, 96:92, 1942.

[6] Unpublished work of the authors.

[7] W. J. Nungester and A. H. Kempf, *Jour. Infect. Dis.*, 64: 288, 1939.

GROWTH OF CORALLORHIZA MACULATA

THE growth of the unbranched scapes of the orchid, *Corallorhiza maculata* Raf., affords an opportunity to observe some phenomena not readily discernible in other plants. The scapes contain no chlorophyll and rise from fleshy, branched coral-like stems which are associated with mycorrhizal fungi, and produce a raceme which may bear as many as 40 flowers.[1] The materials out of which their tissues are formed are entirely derived from the short fleshy stems.

Plants transferred from their habitat under *Sequoia sempervirens* were established in large boxes of soil in the early spring. The initial growth of the scape consisted in the elongation of the embryonic cone with its sheathing scale. As soon as they rose above the level of the soil, measurements and records were started. The first evident development of scapes is the appearance of the enveloping scale above the mass of coralloid stems. Manual examination seems to show that the growing scape inside this scale kept pace with it for more than six weeks on a plant in the open air under natural conditions, where air temperatures ranged from 7° to 17° C., and soil temperatures from 8° to 13.5° C. The growth of the scale ceased shortly after the emergence of the scape.

The growth of the axis, registered on an auxograph which magnified 2.5 times, was negligible for the first week, followed by an acceleration with weekly increases of 4.4, 5.4, 6.0 and 5.6 mm. The tip of the scape was, however, sheathed in a second scale which grew at the same rate, but in time also allowed the tip of the scape to emerge. Between March 7 and April 1 a total height of 65 mm was produced, plus 5 mm after it opened. Its length was, therefore, 70 mm on April 2, measured from an ink-mark representing the level of the tip when the auxograph record was begun. On April 22 the third or uppermost scale had its tip 195 mm above the assumed base, representing an elongation of the internode plus scale of 125 mm since April 2. The elongation of the scale-scape axis suggested that they had a common basal meristem or at least two coordinated meristems.

The third scale emerged March 31 from the tip of its predecessor and it ceased growth on April 30. This third scale arose from a definite node on the scape and, like the second scale it contained no chlorophyll, grew for a short time, then dried out. This growth program was not dependent upon or influenced by light, being similar to that of another plant grown in complete darkness.

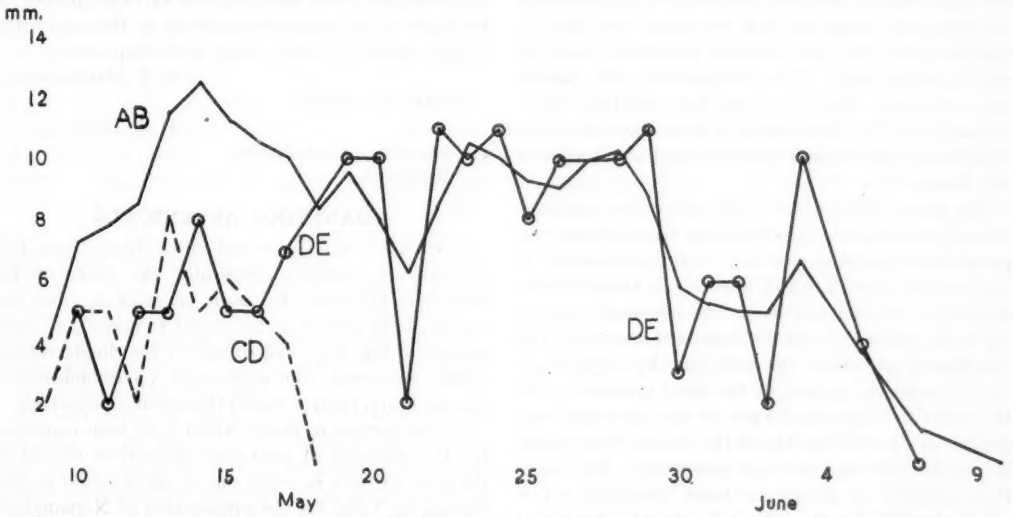

FIG. 1. Daily growth increments of *Corallorhiza maculata*. Ab, smoothed summations; CD, increments from an arbitrary mark near the base of the scape to the lowest pedicel in the inflorescence, showing that elongation of that region ceased May 18; DE, increments from the lowest pedicel to the tip of the inflorescence, showing the continued elongation of the upper region of the scape, and its relation to the part marked CD.

The zone of growth of scales was entirely basal. Derivatives of the meristem passed into a final form above the meristem in contrast to the process of final differentiation in the scape which occurred below (behind) the meristem.

The first phase of the active growth of Corallorhiza (Fig. 1, CD) reached a maximum on May 13 and

[1] MacDougal and Dufrenoy, *Plant Physiol.*, 19: 440–465, 1944.

ceased on May 18, indicating that the tissues below the inflorescence had then reached maturity. The second phase (DE) involving the growth of the inflorescence-bearing axis showed conspicuous irregularity of elongation at the start, but growth was fairly regular from May 19 to 29, then, with some irregularities, diminished and finally ceased June 11. The summation of the two phases (AB) shows that the growth of the entire scape had two maxima: the first of brief, the second of longer duration.

The term scape is here used to designate the flowering shoot of Corallorhiza, although features of growth and anatomical details not yet analyzed suggest that this member includes a reduced vegetative stem terminated by a raceme.

We are now in a position to emphasize certain unique features of the growth system of this plant.

The scape meristem at the base of the first internode is conjoined with that of the first sheathing scale. Its cell division and extension constitute the elongation of the first stages of the scape. Our measurements show that growth during this time is dependent upon growth-promoting substances contained in the basal region. Growth proceeded at a remarkably uniform rate, implying that materials were flowing upward from the base without accretion from the newly-formed cells. The meristematic cells passed into cell layers which in mature form lost their original character, but simultaneously those above that zone took on the meristematic character and produced new cell tracts.

The basal cells of the scape below the meristem passed into a mature condition, but the meristem was progressively pushed upward, carrying ahead of it the terminal portion, which was then in an embryonic condition. During this stage, the internode bearing the third scale was being differentiated above it. The coordinated growth of the node and the scape above it duplicated the growth of the basal internode with the result that the intact apex of the third scale was pushed up through the tip of the second, from which it and the node soon emerged completely. The scape then included an elongating basal internode a few centimeters in length and a similar meristem in a younger stage in the internode above. The salient feature of this activity of two coordinated meristems is shown by the graphs of Fig. 1.

A unique system of translocation of material then prevailed. Carbohydrates and other building materials synthesized in the underground organs were hydrolyzed and moved upward to the meristem and through it to the meristem of the upper internode and then into the embryonic inflorescence. This movement was not, as ordinarily, through vessels, sieve-cells or other conduits, the only xylem element recognized being a few spiral vessels. This feature of solute translocation through an active meristem is unknown in any other plant in so far as the present writers are informed. No effective agency can be predicated. The rate of conduction is so adequate that surplus starch is accumulated through the length of the scape, not excluding the meristematic region.

In the next stage the inflorescence is pushed from the tip of the uppermost scale and is followed by the development of flowers and seed-pods, thus creating a still greater draft on the translocated material. Particular attention was devoted to the influence of the flowers on the rate of elongation of the main axis. The two lower flower-buds diverged from the axis on April 28 concomitant with swelling of the buds. It was noted with great interest that flowers opened only after the region of the axis from which they arose had ceased elongation.

A remarkable feature is the translocation of substances necessary for growth through an active meristem; indeed, during a short period they passed through two meristems. Growth under natural conditions in the open air lacked the salient features of the S-shaped curve characteristic of other plants, as the high rate of acceleration, shown by the summation graph, was in the early stage of development.

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GUANIDINO ARSENICALS

FOLLOWING up the recent work from these laboratories on amidino arsenicals,[1] the study of the guanidino arsenicals has been undertaken, since our search of the literature has failed to reveal any compounds of this type, and certain of the closely related ureido arsenicals, like carbarsone (*p*-ureidobenzenearsonic acid), possess useful therapeutic properties.

Of the various methods[2] which have been employed for the synthesis of guanidine derivatives related to the kind we have in mind, one of the simplest is that utilized by Ville[3] for the preparation of N-guanylsulfanilic acid (I) by condensing sulfanilic acid with cyanamide.

$H_2NC(:NH)NHC_6H_4SO_2OH$ (I)
$H_2NC(:NH)NHC_6H_4AsO(OH)_2$ (II)
$H_2NCONHC_6H_4AsO(OH)_2$ (III)
$H_2NC(:NH)NHC_6H_4As:AsC_6H_4NHC(:NH)NH_2$ (IV)

A similar condensation therefore was attempted between cyanamide and arsanilic acid, and the ana-

[1] Linsker and Bogert, *Jour. Am. Chem. Soc.* (a) 65: 932–935, 1943; (b) 66: 191, 1944.

[2] Bischoff, *Jour. Biol. Chem.*, 80: 345, 1928.

[3] Ville, *Comp. rend.*, 104: 1281, 1887; *Bull. soc. chim.* [2], 49: 41, 1888.

logous N-guanylarsanilic acid (II) was obtained in the form of its monohydrate, as lustrous transparent colorless prismatic crystals, $C_7H_{10}AsN_3O_3 \cdot H_2O$, which lost weight and became white and opaque when heated *in vacuo*. This opaque product, which gave analytical figures agreeing with those calculated for $C_7H_{10}AsN_3O_3$, when heated darkened around 250–260°, gradually turning black but was still unmelted at 350°.

The same guanylarsanilic acid (II) was obtained by the interaction of arsanilic acid, the methyl sulfate addition product of thiourea and alkali, according to the Rathke procedure, as utilized by Wheeler and Merriam[4] for the synthesis of *o*-guanidinobenzoic acid from anthranilic acid. The hydrolysis of this guanyl arsanilic acid to carbarsone (III) is now being investigated.

Preliminary experiments have also been carried out in the reduction of the guanylarsanilic acid to the corresponding 4,4′-diguanidinoarsenobenzene (IV), but the product awaits final purification and identification. The synthesis of other guanidino arsenicals, including derivatives of both tri- and pentavalent arsenic, is also under way and will be reported later.

Full experimental details and analytical results will be published elsewhere.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A STANDARD PENICILLINASE PREPARATION

IN 1943, Lawrence[1] reported that Clarase was capable of inactivating penicillin, and suggested this enzyme preparation as an agent in the sterility test for penicillin. Later, both Stanley[2] and Lawrence[3] showed that the penicillin destroying power of Clarase was due to a bacterial air-borne contamination in the preparation of a specific lot (1351) of the enzyme. Clarase, Lot 1351 of the Takamine Laboratories, Clifton, N. J., is now used in the Official Food and Drug Administration sterility test for penicillin. In a great number of determinations in our laboratories, the use of Clarase has been found to present a number of difficulties. The preparation of the Clarase solution is lengthy and the solution is difficult to sterilize by filtration. From 24 to 36 hours are required to inactivate the penicillin which is to be tested for sterility. A more powerful penicillin inactivating agent which could easily be sterilized and standardized appears therefore very desirable.

Harper[4] prepared penicillinase preparations from paracolon bacilli for use in the sterility test and for inactivating penicillin in blood samples. Ungar[5] described a penicillinase preparation produced from the culture medium of a strain of *B. subtilis*. The preparation was used successfully for both the penicillin sterility test and exudates of body fluids from patients under penicillin treatment. However, neither of the investigators gave quantitative methods of standardizing their preparations. If a material is to be used routinely as a penicillin inactivating agent, it should be of known activity.

Using the bacterium NRRL-B569[6] and a modified procedure of Benedict and Schmidt,[7] we have prepared a very active penicillinase preparation which was sterilized by filtration and standardized according to the method of McQuarrie and Liebmann.[8] Aliquots containing 2,000 penicillinase units were lyophilized and sealed in sterile bottles. Bottles were stored until needed, then diluted with sterile water. The resulting solution was aseptically added to the penicillin sample to be tested for sterility.

The penicillinase was tested for its effect on bacteria likely to be present in unsterile penicillin preparations or in blood samples. In all cases the enzyme preparation had no effect on the growth of these organisms. In fact the growth in those tubes to which penicillinase had been added was more luxuriant than in those to which Clarase had been added in parallel tests. This would indicate the fact that either the nature of the enzyme itself or its associated impurities serve as growth-promoting substances. This may be of distinct advantage in the test.

Samples of penicillin were tested for sterility by both the official FDA method and by FDA method with 100 units of our penicillinase substituted for the Clarase. When Clarase was used a minimum of 36 hours was required for complete destruction of the penicillin. With our penicillinase preparation, less than one hour was required. By adding higher concentrations of the enzyme, an almost immediate destruction can be effected.

Preliminary studies with blood samples from animals infected with *Staph. aureus* indicate that the

[4] Wheeler and Merriam, *Am. Chem. Jour.*, 29: 491, 1903.
[1] C. A. Lawrence, SCIENCE, 98: 413, 1943.
[2] A. R. Stanley, *ibid.*, 99: 59, 1944.
[3] C. A. Lawrence, *ibid.*, 99: 15, 1944.
[4] G. J. Harper, *Lancet*, ii: 569, 1943.
[5] J. Ungar, *Nature*, 154: 236, 1944.
[6] Kindly supplied by Dr. R. D. Coghill, of the U. S. Northern Regional Research Laboratories.
[7] Private communication from Dr. R. G. Benedict, of the U. S. Northern Regional Research Laboratories.
[8] E. B. McQuarrie and A. J. Liebmann, *Arch. Biochem.*, in press.

penicillinase preparation may successfully be used for inactivating penicillin in such materials, thereby allowing the penicillin sensitive organisms to grow on the culture medium. The procedure is similar to the one using para-amino benzoic acid for the testing of sulfonamides in body fluids.

SUMMARY

(1) Standardization of penicillinase has been made possible by the method for its assay.

(2) A purified, dried and sterile penicillinase has been found to be a penicillin-inactivator superior to Clarase for the penicillin sterility test.

(3) Preliminary studies show this penicillinase preparation may be used for inactivating penicillin in exudates of body fluids.

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PENICILLIN TREATMENT OF CROWN GALL

CRUDE penicillin, produced in this laboratory,[1] has cured crown gall on Bryophyllum. The penicillin assayed 2 to 6 Oxford units per cc and was obtained from an improved strain of *Penicillium notatum* contributed by the Northern Regional Research Laboratory, Peoria, Ill. It was made almost automatically and cheaply through the use of a modification of the apparatus described by Clifton.[2] The galls for study resulted from hypodermic inoculations of Bryophyllum with a pure culture of *Agrobacterium* (*Phytomonas*) *tumefaciens*. They were of the "soft gall" type.

From the first hypodermic injections of crude penicillin, just below the galls, the only effect observed was a checking of growth of the gall above the needle punctures, which resulted in an accentuation of the irregularity of the surface of the gall. That effect was interpreted to mean incomplete lateral diffusion of the penicillin in the gall and to indicate as necessary a different method of application.

Penicillin-soaked antiseptic cotton was wrapped around galls and thereafter frequently wetted with crude penicillin. The result of that procedure was the retarded growth and browning of the minute elevations or "pimples" on the surface of the gall. The protective layers of the surface of the elevations appeared to be sufficiently thin for the inward penetration of the penicillin, but elsewhere the drug obviously was kept out of the internal tissues of the gall.

Next, the gall under the cotton wrapping was punctured in numerous places with a sterile needle and soon the tissues began to die and turn brown. Apparent complete destruction of the gall followed. Normal tissues of the stem were somewhat injured where the penicillin-containing cotton wool remained in contact with the surface of the stem, but internally only the gall tissues were affected.

Crown gall is particularly destructive in the Southwest, where the alkaline reaction of the soil, long-growing season, irrigation and heavy transpiration in an arid atmosphere favor the disease.

Penicillin should prove valuable in treating galls on nursery stock and also on set trees and other plants in which the galls are limited to the crown and aerial parts. Cure of the first infected tree in an irrigated orchard frequently would save the entire planting where irrigation would otherwise carry the bacterium and spread the disease. Galls are often seen first at the crown where they may be treated; later they appear on the roots as a result of the downward spread of the gall bacterium. Cure of the crown gall within reach would save not only further spread of infection to the roots of the same tree but, more important, spread of the germ over the field by irrigation water.

The cost of the crude penicillin used in our experiments has been slight. The medium fed to the fungus costs approximately 2 cents per quart and the galls that were cured required a tablespoonful or two of crude penicillin.

Noteworthy is the fact that penicillin apparently destroys, in the case of the crown-gall bacterium, a gram-negative organism. Gram-negative bacteria, in general, have been reported[3] as relatively resistant to penicillin. Interesting, too, is a comparison of the action of crude penicillin on crown gall (often likened to cancer of animals and man) with the reported[4] ineffectual penicillin injection of mice with sarcoma.

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[1] J. G. Brown and Alice M. Boyle, *Phytopathology*, 34: 760–761, August, 1944.

[2] C. E. Clifton, SCIENCE, 98: 67–70, 1943.

[3] For example, see A. D. Gardner, *Nature*, 146: 837–838, December 28, 1940.

[4] Margaret Reed Lewis, SCIENCE, 100: 314–315, October 6, 1944.

BOOKS RECEIVED

KIRSCHENBAUER, H. G. *Fats and Oils. An Outline of Their Chemistry and Technology.* Illustrated. Pp. 154. Reinhold Publishing Corporation. $2.75. 1944.

SAHYUN, MELVILLE and OTHERS. *Outline of the Amino Acids and Proteins.* Illustrated. Pp. 251. Reinhold Publishing Corporation. $4.00. 1944.

WALLING, S. A., J. C. HILL and C. J. REES. *Nautical Mathematics and Marine Navigation.* Illustrated. Pp. ix + 221. Macmillan Company. $2.00. 1944.

The price quoted for the abridged edition of Organic Chemistry by Louis F. Fieser and Mary Fieser is $4.00 not $6.00, as incorrectly stated in the issue of SCIENCE for November 10.

SCIENCE NEWS

Science Service, Washington, D. C.

THE BIRTH RATE

WAR has caused the birth rates in Germany and France to drop considerably. The number of babies born in America and England, on the other hand, has shown a decided increase, according to a report issued by the Metropolitan Life Insurance Company.

Germany's birth rate fell by 25 per cent. from 1940 to 1942, the latest year for which a national figure is available. Figures for the large German cities for the first half of 1943 show a further decline, and in all probability this has continued uninterruptedly.

In France the birth rate had already fallen below the death rate before the country was overrun by Germany. In 1938 only about 14 or 15 children were born for every 1,000 of the French population, and even this was reduced to 13 by 1941. The following year, however, the birth rate surprisingly rose almost to the prewar level.

Italy showed a drop of about 14 per cent. in her birth rate from 1940 to 1942. Since then, with war being waged on her territory, the birth rate there has undoubtedly continued to fall.

"The experience of England has been very different from that of the other countries at war," according to the report. "With most of her men kept within the country, the birth rate in the first years of the war declined only five per cent. from 1939 to its low point in 1941. A sharp recovery in 1942 and a further increase in the following year brought the English birth rate back to the level of fifteen years ago. Current figures for the urban population of England indicate a further rise in the birth rate."

In the few years from 1939 to 1943, the birth rate in America was increased by 27 per cent. The number of births in 1943 exceeded 3,000,000, about 1,000,000 more than during the bottom year of the depression. The birth rate in 1943, 22 per 1,000, was the highest in about two decades.

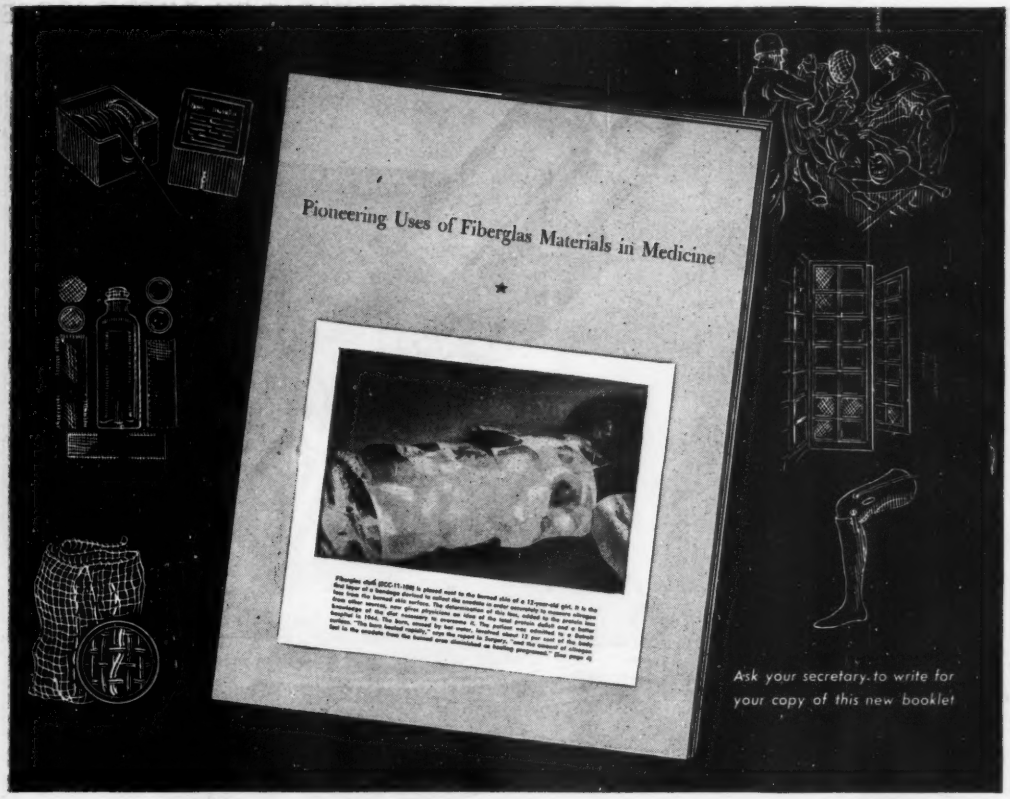
During the present year, despite the fact that husbands are being sent overseas in increasing numbers, in the United States more than 20 babies are being born for each 1,000 population. This is higher than for any recent year except 1943, and there is a good chance that around 3,000,000 babies will be born in 1944.

ITEMS

NEW standards for the amounts of vitamins required in the daily diet and for the amounts of foods needed to supply them may come from discoveries of vitamin factories in the body, it appears from the report of Professor C. A. Elvehjem, of the University of Wisconsin. These internal vitamin factories are operated by bacteria inhabiting the intestinal tract. Scientists a generation or more ago saw the possibility of the intestinal bacteria being related to health and length of life, but the discoveries of their role in synthesizing certain vitamins have been made within recent years. Vitamin synthesis by intestinal bacteria apparently varies in different species of animals. It is impossible, Professor Elvehjem said, to predict from studies with one species of animal, such as rats or dogs, that other species, such as chickens, monkeys or man, will be found to have the same kind of bacterial vitamin synthesis. Bacterial vitamin synthesis also varies, at least in some animal species studied, according to the type of diet exclusive of its vitamin content. In rats, for example, synthesis of riboflavin, one of the B vitamins, is decreased by the presence of fat in the diet. Even the type of fat affects production of the vitamin by intestinal bacteria. The discovery that both thiamin (vitamin B_1) and riboflavin are produced in the intestinal tract of man was made in experiments in which the diet was high in rather pure carbohydrate. "The effect may be quite different in the human living on a typical mixed diet," he said. "In fact, we now have preliminary results which indicate that this is true."

ALL-MAGNESIUM wings on aircraft, fabricated entirely of magnesium, have been in use for over a year on Navy training planes, according to J. C. Mathes, of the Dow Chemical Company, who spoke at the New York meeting of the American Society of Mechanical Engineers. Thirty sets of wings, he said, have been in regular service at naval training stations since early in 1943, and have proved entirely satisfactory. Development work on all-magnesium wings has been under way by the Dow Company, in cooperation with the Navy and the U. S. Bureau of Aeronautics, since 1940. The original set was designed for the Navy's SNJ–2 advanced trainer built by North American Aircraft Company. After static tests and certain minor changes in design in 1942, the 30 sets were ordered. The magnesium wings are 14 per cent. lighter than the standard aluminum wings, and, according to the speaker, are stronger than wings of low-carbon steel, stainless steel, plywood and other materials tested.

TIN cans resist rusting in outdoor exposure in hot humid weather when treated by a new process developed at the Battelle Institute at Columbus, Ohio. The process is the result of research here and in England to develop full protection for food for fighting men in parts of the world where ordinary treatment is not sufficient. In the new method, after the cans are filled, sealed and processed, they are dipped momentarily into a hot solution of alkaline salts. This cleans the surface and produces an invisible film over the tin. No lacquer or enamel is used on the cans, as in present protective processes. Lacquering tin plate to prevent rusting involves expensive and inconvenient operations in the manufacture of cans. The hot alkaline process is readily adaptable to production lines in canneries. Protection against corrosion may not be quite as good as lacquers under some conditions, but it appears to be adequate for most purposes. The mechanism of the new process is not definitely understood as yet. However, tests show that pinhole corrosion is effectively delayed and the cans stay bright and clean after weeks of outdoor exposure.



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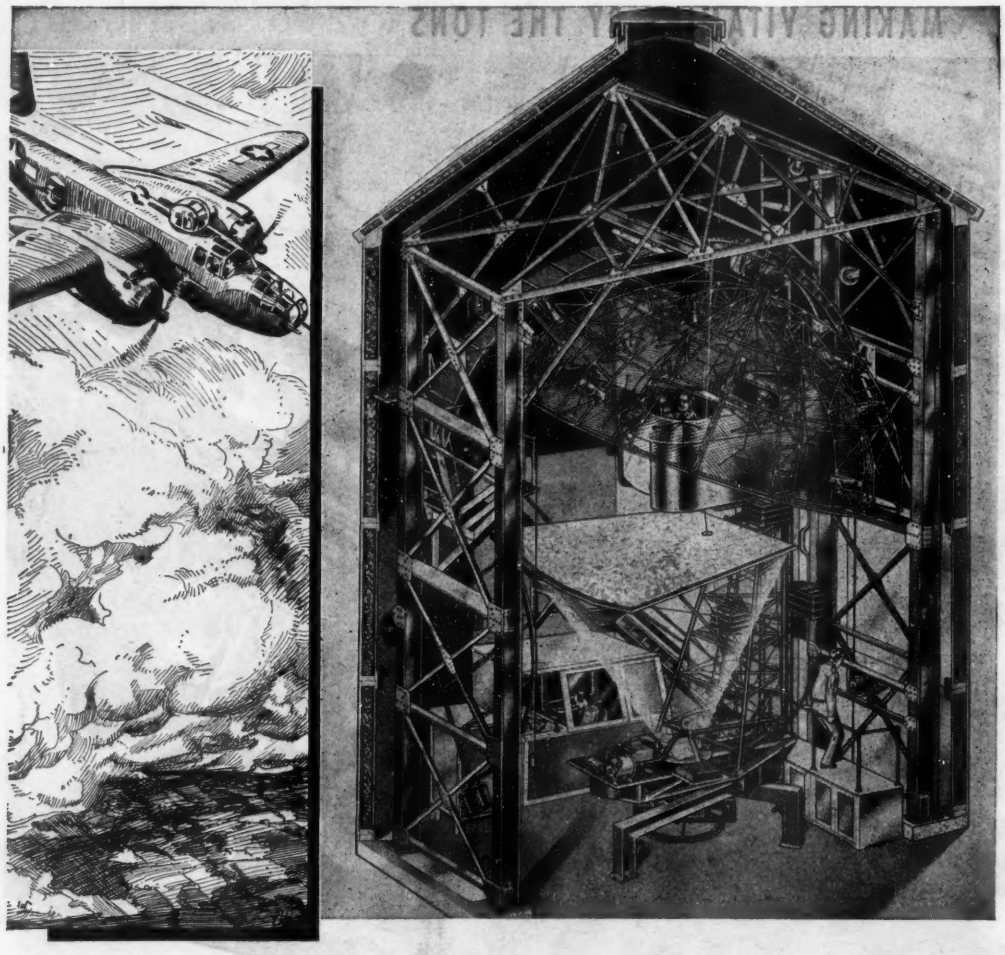

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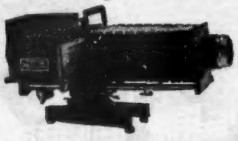

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